SkySpark® Everywhere™ - The Industry-Leading Software Platform for IoT Applications in the Built Environment

Introducing the industry's most advanced edge-to-cloud, distributed, data-and-compute technology platform

Build IoT applications for a fraction of the cost and development time versus assembling bits and pieces of IT technology

SkyFoundry

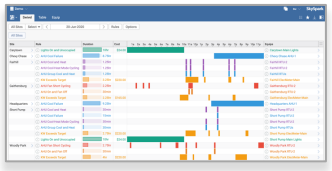
The IoT Data Platform For Applications in the Built Environment

The application of the IoT in the world of the built environment – the structures that humans have created to house our lives and industries (the BIoT) – presents unique challenges for data and computing applications.

The first challenge is the type of data. The equipment systems, devices and sensors that populate our environment create vast amounts of data – data of a special type – time series data. Industrial historian software has historically been used to handle this type of data, but do not address two essential aspects required for IoT applications – the ability to capture the meaning of data and the relationships between different data items. To address these requirements, technology often referred to as to document-oriented databases and graph-oriented databases are needed. But you can't effectively address IoT applications with multiple databases. You need a single database technology that embraces all of these design requirements. SkySpark's Folio database, the foundation of the SkySpark Everywhere platform, does just that.

What We Are Known For - Creating Value from Device Data -

By automatically detecting patterns that represent deviations, anomalies, faults, and opportunities for savings



SkyFoundry is most well-known for our **SkySpark®** analytics software which automatically analyzes data from automation and control systems, metering systems, sensors and other smart devices to identify issues, patterns, deviations, faults and opportunities for operational improvements and cost reduction.
Today, SkySpark has been deployed across over 1 Billion sq. ft. of built space in more than 15,000 facilities by our worldwide network of Value-Added Resellers – systems integrators, engineering firms, M&V professionals and facility monitoring service firms. They use SkySpark as the foundation to deliver their services to their customers.

What is less well known is the comprehensive technology platform that underlies SkySpark – a platform we make available to OEM's. This core platform, known as SkyArc, enables OEMs to build software and hardware products for IoT applications, and do so more quickly, efficiently, and deliver greater reliability, more features, all with a dramatically shorter time to market.

This paper provides an overview of the capabilities of SkyFoundry's SkyArc software platform.

SkyArc™ – The Data-Centric Software Platform for BIoT Applications

What's Different About It?

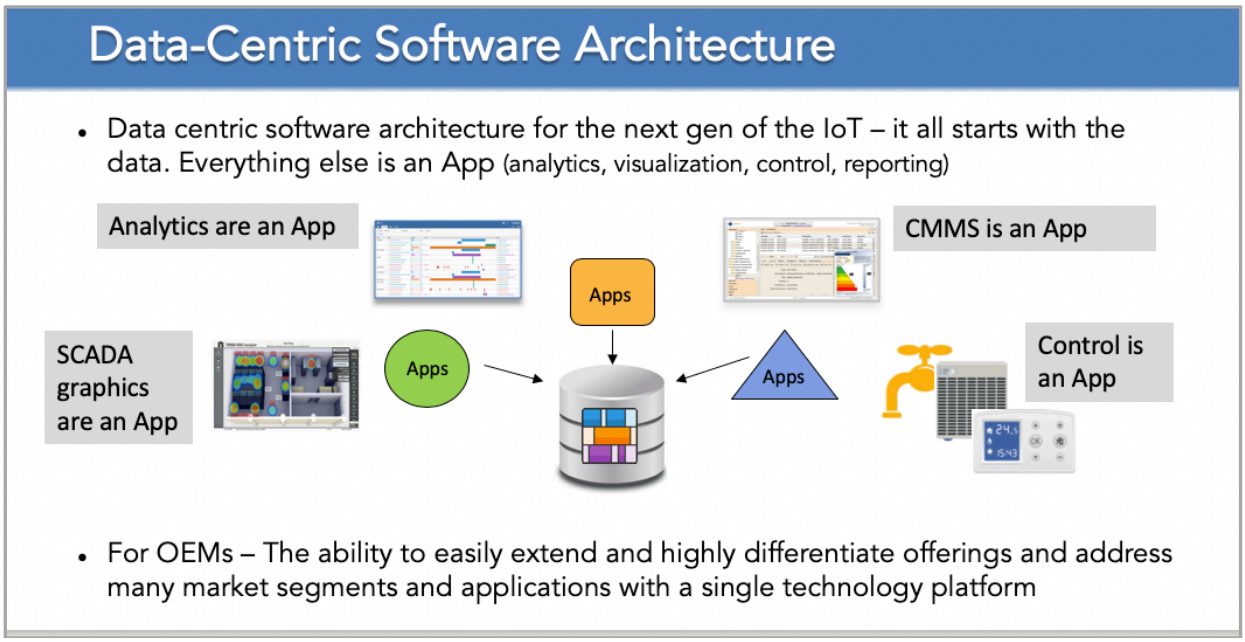
Why do tier 1 companies rely on an external company for their core IoT technology?

Because of SkyFoundry's edge-to-cloud deployment architecture, high-performance database, analytics engine, data visualization applications and extensible platform and proven results.

The key differences in SkyFoundry's approach start with SkyArc's **data-centric design** – meaning that data is at the center of the design. Most existing products are based on the "control-centric" architectures initially developed in the 1990's and even earlier. That approach cannot support the features sets and scale needed for the next generation of data intensive IoT applications.

Control-centric design means that the software framework was designed primarily to serve the needs of sequential control of outputs, based on sensor inputs. The use of the sensor and control data and ability to consume and make decisions on other types and sources of data was very limited or non-existent. For example, automation controllers typically do not provide the ability to import data files, query external databases, assimilate that data and then analyze it for patterns to make decisions, or present analysis of that data to users. Their primary purpose in life is to read a sensor value, process some logic and control an output, whether it be an on/off relay or an analog signal to a valve or other modulating device. Control functions of this type are still required, but they stop short of meeting the needs of more advanced IoT applications.

In SkyFoundry's data-centric design, everything starts with a core designed to work with data – data of all types, coming from all types of sources, in different formats and on different time frequencies. Functions like sequential control are simply an "app" that draw on that data to perform the desired control functions. But with a data-centric design, other "apps" can simultaneously use data to serve other functions. Commonly used tools like CMMS and work order systems, equipment graphics and analytics are simply "apps" that work on top of the core data services.



With comprehensive handling of diverse machine, equipment and asset data as the core capability, virtually any other service can be layered on top as an app. The result is a **data centric platform** that can serve multiple application needs, all on the same foundation, using the same tools, programming language and code base.

No longer do application developers need to deal with the complexities of control-level operating systems and languages designed to serve the needs of control logic. They are free to quickly build their Apps against a cleanly abstracted data service.

And… Perhaps the Most Important Differentiator

Edge-to-Cloud Distributed Computing Architecture

Cloud-only solutions cannot meet on-premise and equipment-level needs

We hear lots of talk about the "cloud" as it relates to the IoT to the point that it seems like the "cloud" is considered as the solution to all things IoT. The IoT is actually a distributed computing challenge. The reality is that it is not possible, cost effective or desirable to transmit every piece of data from every IoT device to the cloud in order to gain value from that data. An IoT solution needs to support the highly distributed, non-hierarchical and multi-vendor nature of the IoT by providing a software architecture that matches those needs.

> *"The reality is that it is not possible, cost effective or desirable to transmit every piece of data from every IoT device to the cloud in order to gain value from that data.*
>
> *An IoT technology platform needs to recognize and embrace the highly distributed and innately non-hierarchical nature of the IoT and support that with a corresponding software architecture."*
>
> Harbor Research

Think about it. We live in a distributed computing world. Bring up your browser. On your PC, your phone or your tablet… Go to Yahoo or Google or your favorite site. Look up a subject of interest. Do a search. Boom! There it is. The information you wanted.

How did that happen? Did you upload and centrally store all of the information to your computer first? On your cell phone? On your tablet? No.

Is all of the information stored on a single server somewhere in the cloud? Did someone have to aggregate and store it on a single server in order for it to be to be searchable, accessible, viewable? Obviously, the answer is no.

You request what you want when you want it. You search for what you want when you need it. You subscribe to news feeds that interest you. But you don't try to aggregate it all on one server. Because you can't. And there is no need to.

Nothing else on the web works that way. Search doesn't work that way. When you type in a search your request is dispatched to hundreds or thousands of computers. They all respond and then their results are shown to you in a way that makes it look like they are somehow in a single location.

So why do people think they have to bring every piece of data from hundreds, thousands, millions or billions of devices to a single server in order to be able to use that data, visualize it, analyze it present it, and gain value from it?

The answer, in our view, is simple. They are trying to solve a distributed computing challenge with a centralized data approach. A platform that properly addresses the needs of the BIoT must embrace the highly distributed and innately non-hierarchical nature of the equipment and devices that make up the built environment. It needs to provide an edge-to-cloud architecture that enables computing to occur where it is most efficient, cost effective, and reliable.

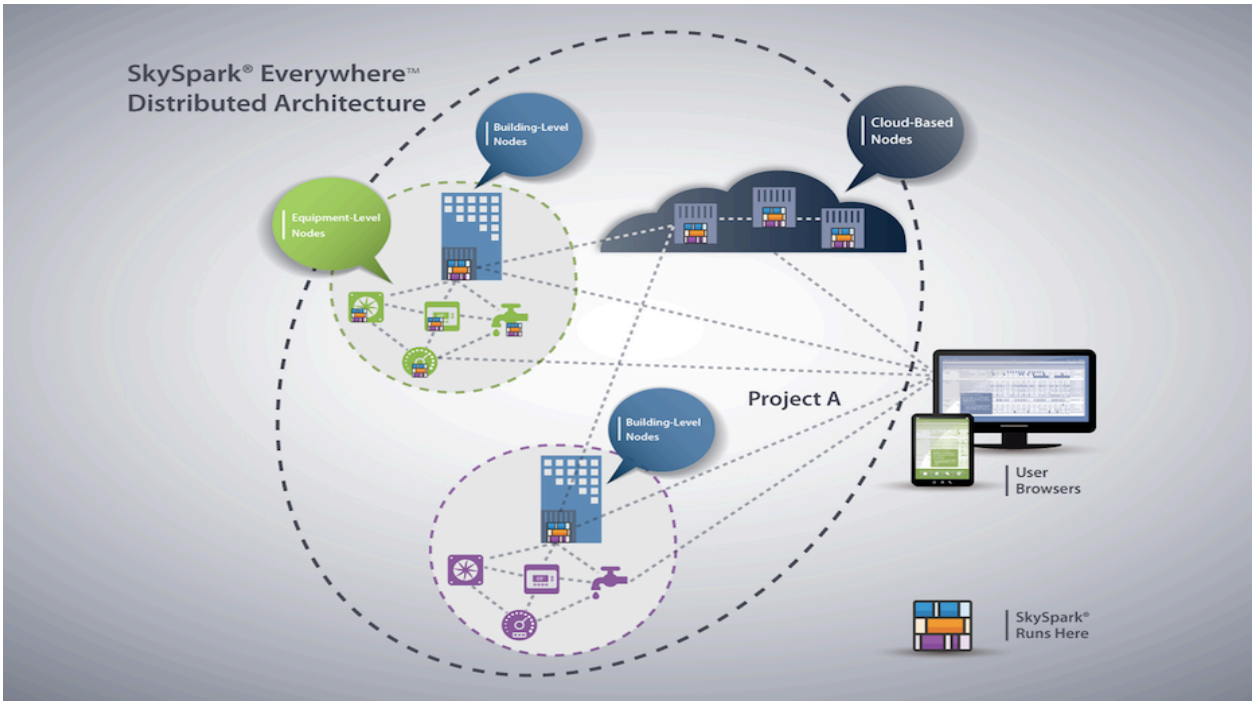
Consider the example of a self-driving car. We can't be dependent on sending data to the cloud before deciding to activate the brakes. That data analytics process needs to occur in the vehicle – at the edge. Yet other applications are better served by aggregating data on a central server. Consider how mapping applications collect and analyze GPS data from mobile phones to identify traffic jams and direct us to the best route to our destination. That application is better served by the cloud. The self-driving car example highlights the "data latency" reasons we need to perform data analytics at the edge, but there are others.

When we talk about analytics at the "edge" we are referring to performing data acquisition and analytics functions as close to the data source as possible. For example, running the SkyArc platform on small IoT devices mounted directly on equipment systems or embedded within equipment controllers.

The ability to process data acquisition and full computing at the edge provides important benefits for many applications. Some of those benefits include:

- Greater reliability of data collection, processing and user interaction
- Reduced data latency – to support "real time" processes
- Isolation of Fieldbus Networks that are not secure enough to go over the Internet
- Reduced data transfer costs and better performance on "constrained" (slower or expensive) networks – if data processing functions like analytics our alarming are processed at the edge, the only thing that has to go across the network is the end result – not all of the data that had to be analyzed to get to that result
- Improved application reliability and process continuity
- Engineer the system once – architectures that require different code bases and toolsets to be used at different levels of the architecture result in substantially more engineering effort and risks to reliability

SkyFoundry's Edge-to-Cloud Distributed IoT Architecture



- The full software feature set - data collection, storage, processing and analytics is *performed at all levels of the architecture*
- Distributed "nodes" work together in seamless, unified systems called clusters
- Nodes can be small embedded devices, controllers, "edge gateways", on-premise servers or cloud-hosted servers – full feature set is runs everywhere
- Provides maximum flexibility, scalability, reliability, and simplicity to meet real the world application needs of distributed IoT systems
- *Requires fundamentally different software technology than provided by cloud-based solutions*

Key Requirements of an IoT Software Platform

Virtually all of SkyFoundry's OEM customers had invested significant development effort into building their own solutions or were in the process of planning that effort. Applications typically share these core requirements:

- Communication – Connectors to access data from external devices, systems and applications
- Database technology optimized for efficiently managing huge volumes of "machine data" (time-series, multi-structured data)
- Historian functions/services optimized to query, and process large volumes of timestamp value pairs
- Analytics engine – to automatically run rules and algorithms against the data
- Visualization – ready-to-go Apps that automatically generate rich displays of data and results, and tools that allow users to create their own reports and interactive Apps
- Scalable, Distributed Computing architecture to support large-scale systems with multi-server clustering
- Compute at the Edge – the ability to run entire stack on low cost widely deployable hardware, and embed software applications small, proprietary, low cost edge devices with cost points and horsepower in the range of devices like the Raspberry Pi or Beaglebone
- Open API's – to enable integration with third party applications to put data into the platform and get data and analytic results out – example: automatically generate workorders in a CMMS
- Multi-tenancy support – a single server can host multiple customers, each with their own secure data realm
- Security: Certificate based authentication, TPM integration, HTTPS in the browser, LDAP support for centralized credential management and SSO
- Automatic notification of detected issues via email with hyperlinks and report attachments

Direct Connection to Data Sources via a wide range of communication protocols – eliminates cost and complexity of gateways

High Performance Database – handles truly big data – billions of data samples

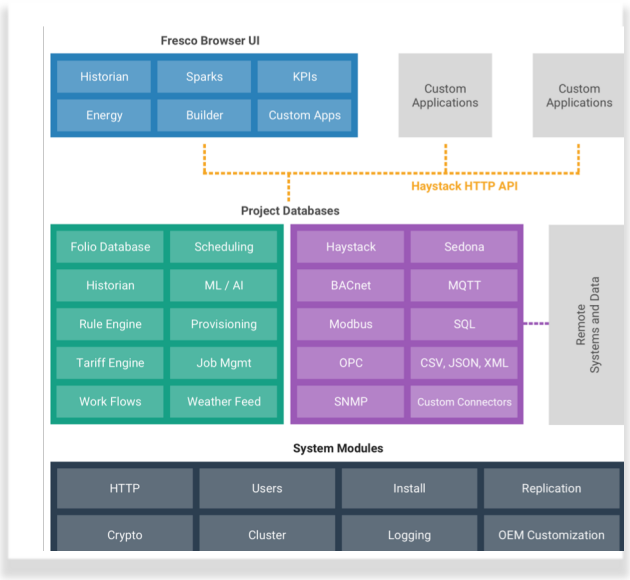
Unified End-to-End Platform – compelling buy-vs-build economics

Extensible for OEM Differentiation Allows OEM's to differentiate their offerings, not simply by offering white labelling, but by providing the tools that enable OEMs' to build their own value-add on the platform.

SkyArc platform is designed to provide OEMs with full ability to differentiate their offerings.

SkyFoundry's SkyArc technology provide all of these capabilities in a ready-to-go, end to end platform, that also allows OEM's to extend and differentiate their offerings.

What the SkyArc™ Platform Provides



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- Requires fundamentally different software technology than provided by cloud-based solutions
- Scalable, distributed architecture – the SAME code base runs in small edge devices and the cloud
- ADVANCED DATA COMPRESSION - Highly efficient data storage >10 times more efficient than relational databases - Time stamped data sample stores in 12 bits (compare to SQL at ~35 bytes)
- Integrated, high-speed analytics processing engine with advanced functionality
- Read Performance: Even on a run-of-the-mill machine benchmarks for querying are 800,000 samples/sec. To crunch a year's worth of 15 minutely data is only 30ms!
- Communication connectors to major device protocols: Bacnet IP, Modbus TCP, Obix, Haystack, SNMP, Sedona, OPC UA, MQTT, SQL, CSV import (manual batch or automated), and a REST API and includes a connector development toolkit

- Extensible with a wide range of tools for OEM customization – true software platform
- Cloud or on-premise deployment
- Lower Total Cost of Ownership than data technologies designed for business IT use
- Proven – widely deploy in a range of vertical market applications

Why We Need Compute-at-the-Edge

How SkySpark's Edge-to-Cloud Architecture Addresses Key Challenges for Next Era of the IoT

- Greater fault tolerance – for data collection, storage and processing – Collect data, process analytics and create visualizations as close to the source as possible
- Low latency (near real-time) processing of analytic rules and algorithms
- Support applications with "constrained networks" - intermittent connections, or high cost data transfer (i.e., cellular connections)
- Engineer once – one application environment - set up data acquisition and tagging once – eliminate the multiple engineering steps required when using different edge devices each with their own software environment
- Provide a seamless, responsive, user experience across multi-node systems
- Meet regulatory requirements for data storage location- keep data within a region or jurisdiction
- Security – keep data on premise - meet requirements for projects that cannot send data to an external cloud
- Isolate in-building systems from the Internet – acts as a security barrier
- Reduce costs – eliminate gateways and security appliances in many applications
- Seamless User Experience – provide a seamless, responsive, user experience across multi-node systems that include data from multiple systems – they appear to the user as a single seamless system

Deploying at the Edge

Runs on Small, Low-Cost IoT Hardware, PC's Servers and Cloud Platforms

Designed from the ground up for embedded applications

Runs entire application effectively on platforms as small as Raspberry Pi Zero and Beagleboard Black

Now everything can be connected!

Our Supported Test Platform:

1 GHz processor and 512 MB RAM for 1000 points
Our test platform:
http://beagleboard.org/black
JVM: Pre Java 9 — Oracle JVM

Digital Twins

The term "digital twin" has entered the lexicon of the built environment in recent years. The concept is to create a digital representation of facilities and equipment systems which can be used in a range of analysis application. The Industrial Internet Consortium (https://www.iiconsortium.org/) defines a digital twin as follows:

> A formal, digital representation of an asset, process or system that captures attributes and behaviors of that entity suitable for communication, storage, interpretation or processing within a certain context. Digital twin information includes, but is not limited to, combinations of the following categories: physics-based model and data, analytical models and data, time-series data and historians, transactional data, master data, visual models and computations.

SkySpark's Digital Data Replication:

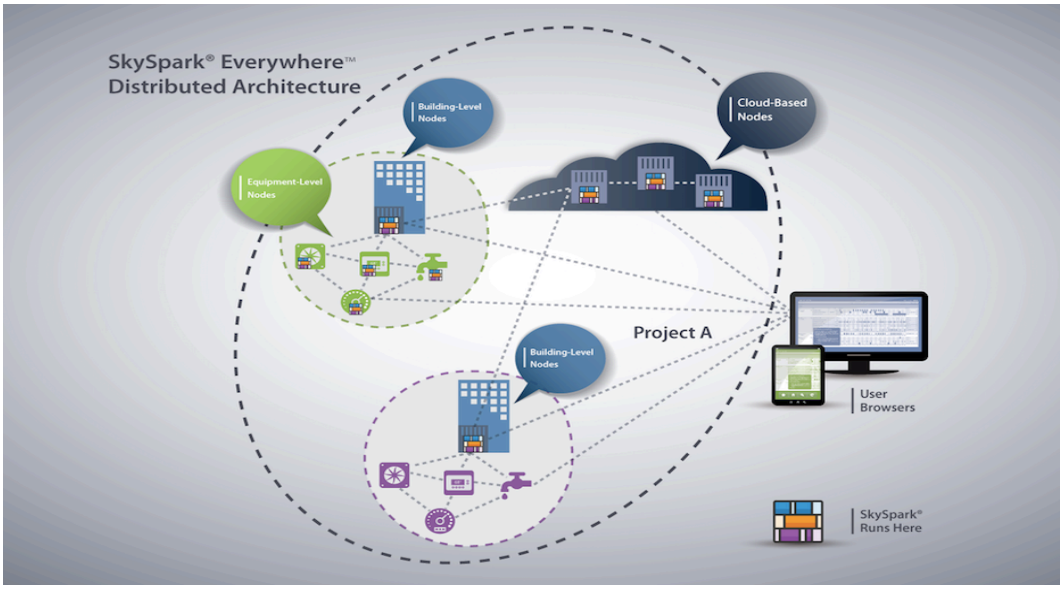
Going Beyond the Single Digital Twin

Even with a distributed architecture that spreads data collection, storage and computation over multiple computers, there is often a need to be able to "replicate" data to create a comprehensive digital replica. The key is to be able to do it in a way that does not create limitations for users, who may have a range of very different needs. A cornerstone of SkyFoundry's approach to the challenge is to go beyond the concept of a single "twin" and instead provide the ability to have multiple digital replicas of the data contained by distributed nodes.

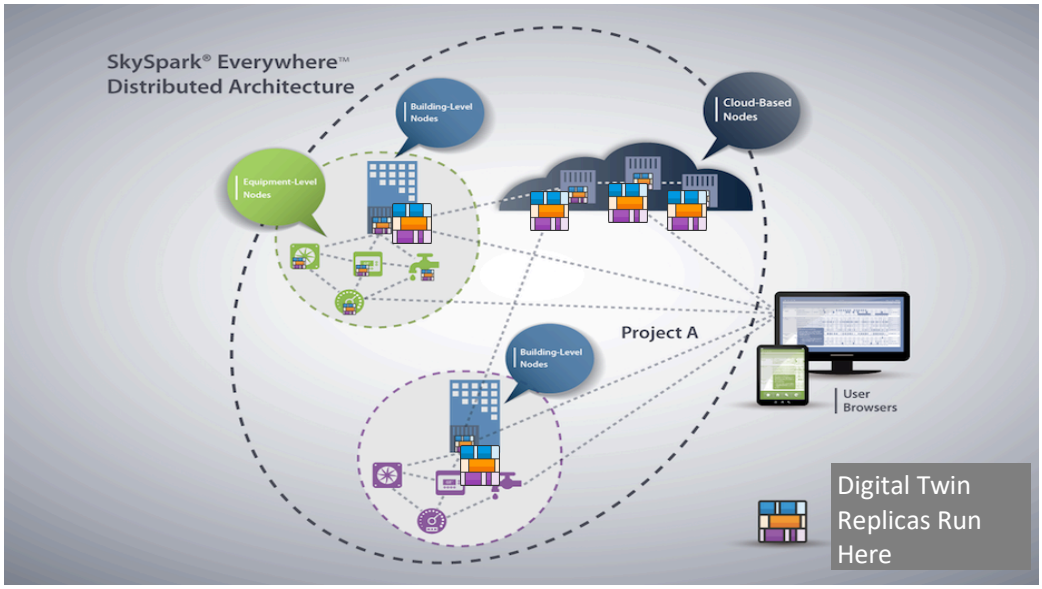
SkySpark's automated replication technology provides a fully operational replica of each node in a distributed system. Users can interact with that replica to run reports, perform analytics, evaluate KPIs - EVEN WHEN the actual node is OFFLINE. User queries do not have to penetrate down to the actual nodes. Instead they work with last available data. One benefit of this approach is saving significant data transfer costs.

SkySpark's replication technology also provides a full, automated backup of individual nodes saving time and effort versus other methods of backup.

To help convey the power and capabilities of SkyFoundry's digital replica technology let's take a look that the following architectures diagrams. First let's review the distributed architecture example shown earlier:



Now let's overlay that with replicas. Note that multiple replicas can be created at all levels of the architecture, providing maximum flexibility to meet diverse project requirements.



Summary – SkyFoundry Provides Strategic Value for OEM's Planning to Offer IoT Services and Products to Serve the Built Environment

SkyFoundry provides OEM's with unified, data-centric application platform that in turn enables them to move to a uniform hardware design for next generation products. Core hardware platforms can be optimized while application developers work in an environment that keeps them out of the messiness typically found in application development for embedded devices.

- Single development environment from edge devices to the cloud – streamlines development – one set of tools, API's, and resources to build applications across all applications - BAS, Lighting, even Fire and Security
- Faster, more cost effective, development - App developers do not need to be skilled in lower level software complexity – they work on a clean application layer – the platform handles the messy stuff and gives them access to the data they need
- Build more with less effort – applications can run on all hardware
- Comprehensive IoT data platform – streamlined development, reduced hardware cost, ability to extend and differentiate as needed
- Deploy on premise, in the cloud or embedded in hardware products
- User programmable - Empowers the channel to deliver next era of intelligent building services
- Proven technology – widely deployed

Extensible for OEM Differentiation

A true OEM platform has to allow OEM's to differentiate their offerings, not simply by offering white labelling, but by providing the tools that enable OEMs' to build their own value-add on the platform. Value -add might consist of specialized Apps, data visualization tools, communication connectors, engineering tools optimized for their products, analytic rule sets, and other extensions of functionality unique to the OEM. The SkyArc platform is designed to provide OEMs with full ability to differentiate their offerings.

Learn More

We encourage you to contact us to learn more about SkyFoundry, our SkyArc platform and SkySpark analytics application for OEM's. We will be happy to provide all of the detailed information you need to substantiate our claims and enable you evaluate SkyFoundry technonlogy for your applications – from embedded hardware to cloud-based, and hybrid applications.

ABOUT SKYFOUNDRY

SkyFoundry's mission is to provide software solutions for the age of "the Internet of things". Areas of focus include:

- Facility Automation and Management
- Remote device and equipment monitoring
- Energy management, utility data analytics
- Asset management

SkyFoundry products help customers derive value from the data in smart systems. Contact us to learn more.

SkyFoundry